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Are young generations in secondary school digitally competent? A study on Italian teenagers

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ABSTRACT

Digital competences amongst the younger generations and the role of schools faced with the spread of new youth practices are topics of increasing interest. Some commentators state that, thanks to the intensive use of digital media, young people are developing significant competences that also correspond to important cognitive processes and new learning styles. However, other authors emphasize that there is no evidence about the positive impact of new technological practices on the development of significant cognitive abilities.

In this paper we present a research study carried out in Italian schools on adolescents' (aged 14–16) digital competence. On the basis of a preliminary theoretical model, a digital competence questionnaire was formulated and subsequently administered to a sample of secondary school students.

The aim was to verify whether adolescents' digital skills are limited to simple technical aspects or expand beyond them including a range of more significant knowledge and skills related to a conceptual understanding of technology, socio-relational knowledge and high-order cognitive skills. Like other studies, this research shows that when attention is shifted from strictly technical aspects to critical cognitive and socio-ethical dimensions involved in the use of technologies, students' knowledge and competences result inadequate. The authors conclude that the optimistic portrayal of younger generations' digital competences is poorly founded. Furthermore, it is pointed out that understanding students' digital competence levels through fast assessment tools is a fundamental opportunity for schools to analyse deficiencies and prepare adequate intervention strategies.

1. Introduction

In the past few years vast literature has developed around the idea that a new generation of students – defined as 'digital natives' (Prensky, 2001a, b), 'millenials' (Howe & Strauss, 2000), netgeneration (Oblinger & Oblinger, 2005; Tapscott, 1997, 2008), 'homo zappiens' (Veen & Vrakking, 2004), instant messaging generation (Lenhart, Rainie & Lewis, 2001), New Millennium Learners (Pedrò, 2007) – is entering educational institutions. Several commentators maintain that this generation, which grew up using ICTs intensively, has developed sophisticated technological abilities and new cognitive styles (Dede, 2005; Howe and Strauss, 2000; Oblinger & Oblinger, 2005; Prensky, 2001a; Tapscott, 1997; Veen & Vrakking, 2004). Prensky (2001b) emphasizes on generation differences by comparing digital natives, who developed familiarity with technologies in a natural way, with digital immigrants, who learnt the new ICT languages. Veen and Vrakking (2004) maintain that 'homo zappiens' is able to deal critically with a great amount of digital information, managing to distinguish between reliable and unreliable information. Dede (2005) goes further and maintains that the use of web 2.0 technologies has favoured the development of attitudes aimed at participation and knowledge collaborative building. They all come to the conclusion, often expressed in dramatic tones provoking a sort of moral panic (Cohen, 1972), that educational systems are now obsolete when confronted with the needs of new generation students.

Nevertheless, such portrayals of digital natives have recently been called into question by various sources, both on a theoretical (e.g. Bennet, Maton, & Kervin, 2008; Selwyn, 2009) and an empirical level (e.g., Bullen, Morgan, & Qayyum, 2011; Kennedy, Judd, Churchward,

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Gray, & Krause, 2008). First of all, what is called into question is the legitimacy of talking of a whole generation having common digital traits in terms of access and use of technologies. Surveys on a wide scale show that the models of technology access and use vary considerably amongst students (Kennedy, et al., 2007; Kvavik, 2005; Kvavik, Caruso, & Morgan, 2004; Margaryan & Littlejohn, 2008; Thinyane, 2010), and are strongly conditioned by socio-cultural and economic factors (Nasah, Da Costa, Kinsell, & Seok, 2010). Students' activities concentrate on tools such as electronic mail, mobile phones, the Internet and social networks. Few students create personal multimedia contents or are familiar with more advanced technologies and services like virtual worlds, collaborative work spaces, online publication tools (Kirkwood & Price, 2005). Moreover, when they access Internet resources, they reveal low attention to the validity of contents, a widespread passivity and lack of critical thought and judgment (Bennet et al., 2008; Eagleton, Guinee, & Langlais, 2003; Kuiper, Volman, & Terwel, 2005; Lorenzo & Dzuiban, 2006; Ravestein, Ladage, & Johsua, 2007).

Indeed, attaining an adequate assessment of younger generations' digital competences is difficult, due to the different socio-cultural conditions of the subjects addressed, the different theoretical reference modals and the lack of available empirical data. In fact, even though there are some large-scale and relevant studies on specific aspects (see, for example, OECD, 2011), anecdotal accounts mainly prevail and empirical data are often limited to the collection of users' declarations about their frequency and ways of using technologies.

The aim of this paper is to contribute to the understanding of 'digital natives' skills and their possible implications for education. First, we defined a digital competence model in line with the main suggestions given in the literature. Then we formulated an assessment tool suitable for rapid application on a wide scale (i.e., the Instant Digital Competence Assessment, iDCA), and we administered it to adolescents between the ages of 14 and 16 in a survey within Italian secondary schools. The question asked is: Does digital literacy amongst younger generations consist only of technical-practical knowledge and skills or does it also include a conceptual understanding of technology, socio-relational knowledge related to the web and high-order cognitive skills which could be involved in their use?

2. Theoretical background

2.1. Definitions of digital literacy and competence

Many different research traditions have emerged over the last decades in the theoretical reflection on the educational use of new technologies. Each is based on specific assumptions on the relationship between ICTs and education, depending on specific cultural and historical background. On the one hand, issues on teaching and learning have been of interest in media education, a research field with a long tradition in Europe (Buckingham, 2003; Jacquinot, 2001; Masterman, 1985), United States (Hobbs, 1994) and Canada (Piette, 1996). In particular, the term "media literacy" had begun to circulate in the 1970s and today is widely used. It refers to the knowledge, skills and behaviour, which enable a person to read and write the media, and to make active and conscious use of them (Buckingham, 2003; Celot & Tornero, 2008; Jacquinot, 2009).

On the other hand, an input to the reflection on literacy comes also from Information Literacy studies, a field of research that has mainly developed in library science since 1970s. Recently, the Association of College and Research Libraries (ACRL, 2000) promoted a new definition of Information Literacy, where the capacity to determine the nature and extent of the information and the ability needed to evaluate it critically are essential components.

With the spread of digital technologies in the last thirty years terms such as computer literacy or IT literacy have prevailed, with a strong focus on technical aspects (Bruce & Peyton, 1999; Davies, Szabo, & Montgomerie, 2002; Swan, Bangert - Drowns, Moore-Cox, & Dugan, 2002). These expressions, however, have given way to the term digital literacy, shifting the focus to cognitive, reflexive and socio-relational dimensions (ETS, 2002). For example, Gilster (1997), who first used and defined the term digital literacy, emphasises critical thinking ability rather than IT skills. Tornero (2004, p. 31) stresses the mixed nature of digital literacy defined as a combination of: "purely technical aspects, intellectual competences and also competences related to responsible citizenship". Likewise Martin (2005, p. 153) defines digital literacy as "the awareness, attitude and ability of individuals to appropriately use digital tools [...] in order to enable constructive social action; and to reflect upon this process". Gapski (2008) articulates digital literacy into two main strands: "instrumental-technological" and "normative media-educational" corresponding respectively to usage/functionality, and pedagogical aims.

Another theory is advanced by Hobbs (2010, pp. vii–viii), who provides a comprehensive framework for "digital and media literacy", defining it as the ability to: "(1) make responsible choices and access information [..], (2) analyze messages [..] by evaluating the quality and credibility of the content, (3) create content [...], (4) reflect on one's own conduct and communication behaviour by applying social responsibility and ethical principles, and (5) take social action by working individually and collaboratively to share knowledge and solve problems [...]".

Even Eshet-Alkalai and colleagues (Aviram & Eshet-Alkalay, 2006; Eshet-Alkalai, 2004) have developed a global framework for the digital literacy concept. These authors point out that "digital literacy has become a "survival skill" in the technological era — a key that helps users to work intuitively in executing complex digital tasks" (Eshet-Alkalai & Amichai-Hamburger, 2004, p. 421). As such, digital literacy entails more than the mere ability to use software and includes five types of literacy: photo-visual literacy, reproduction literacy, information literacy, branching literacy, and socio-emotional literacy.

As regards international organisations, in the U.S. the International Society for Technology in Education (ISTE) developed the National Educational Technology Standards (NETS-S) and Performance Indicators for Students. According to NETS-S, a digitally literate student demonstrates critical and creative thinking, is able to use digital media to work collaboratively and to gather, evaluate and use information, and understands societal and ethical issues related to technology. Since 2008, this standard has provided the theoretical framework in the U.S. for the development of various instruments for the assessment of IT literacy (ISTE, 2007). In this context, the National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Assessment (NAEP, 2010) further defines technology and engineering literacy as the capacity to use, understand and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals.

In summary, from a study of the literature and of the different models proposed in the different contexts, independently of the terms used, the following trends seem to emerge:

- agreement that digital literacy is broader than ICT literacy and includes other elements, such as information literacy, media literacy and visual literacy;
- wide consensus on the need to shift the focus from mere technical mastery towards the identification of higher-order cognitive skills and socio-ethical-relational issues related to the use of technologies.

2.2. The Instant Digital Competence Assessment (iDCA): theoretical foundation

The digital competence model we adopted stems from reflections on the relationships between the mind and the medium, as they have historically emerged, and the related socio-cultural connotations (Bolter, 2001; Goody, 1986; Havelock, 1986; Ong, 1982). Reflecting on how the mind-medium relationship has been articulated in the past thirty years can help identify some crucial dimensions. In the 1980s and 1990s, along with the spread of personal computers, reflections on the potential of technologies as “tools” or “cognitive amplifiers” started becoming more significant (Jonassen, 2000; Pea, 1985; Salomon, Perkins, & Globerson, 1991). This underlines how profitable cognitive partnerships can be established between the brain and the medium, which enable the brain to activate high-level cognitive processes (like formulating hypotheses and verifying them immediately). In the 1990s and 2000s the Internet became very popular, which led to the need for greater ability to select and critically assess information. This is a crucial dimension through which schools can find the way to redefine the meaning of their identity and mission (Lévy, 1997; Rheingold, 1997; UNESCO, 2008).

It was also noted that technologies could become amplifiers of collaborative competence (see Computer Supported Cooperative Work experiences; Carstensen & Schmidt, 1999; Winograd & Flores, 1986). At the same time, the Web was viewed as an environment for new forms of collective intelligence (Lévy, 1997). Due to the development of Web 2.0 and the consequent emphasis on participatory culture, the focus was shifted to socio-ethical aspects (James et al., 2009; Jenkins, Purushotma, Weigel, Klinton, & Robison, 2009).

In short, the last thirty years of digital technology have highlighted how some fundamental educational challenges can and must be identified in the opportunities and risks generated by mind–media interaction: such awareness should guide any reflection on an educational model of digital competence.

Starting from this theoretical and historical basis, we have chosen some real world situations as benchmark models to identify a digitally competent person (Inquiry, Simulation, Collaboration, Participation, see Calvani, Fini, & Ranieri, submitted for publication).

Once knowledge of these models has been elicited and represented, a component breakdown process can be carried out according to the approaches adopted in complex learning and in Cognitive Task Analysis (CTA) (Crandall, Klein, & Hoffman, 2006). This analysis, carried out by a panel of experts and taking into consideration aspects that emerged in current literature, resulted in the emphasis on particular types of knowledge and skills related to technological/cognitive/ethical dimensions, which have been considered to identify the items in the test (see below).

2.2.1. Types of knowledge

Visual literacy (VL): useful knowledge for recognising icons, symbols, interfaces.

Trouble shooting (TS): operative knowledge that helps in solving common technological problems. Most of this knowledge is acquired through practice.

Understanding Technological Concepts (UTC): knowledge relating to technological functioning, computer potential and concepts and procedures pertaining to logic (e.g. using logical operators).

Ethical Knowledge (EK): knowledge needed to behave in an ethically accepted manner, even though having such knowledge does not imply behaving ethically. Here, we can distinguish between knowledge related to privacy (*SSO*), respect for others (*RON*), and knowledge of technology’s socio-cultural implications (*USTI*).

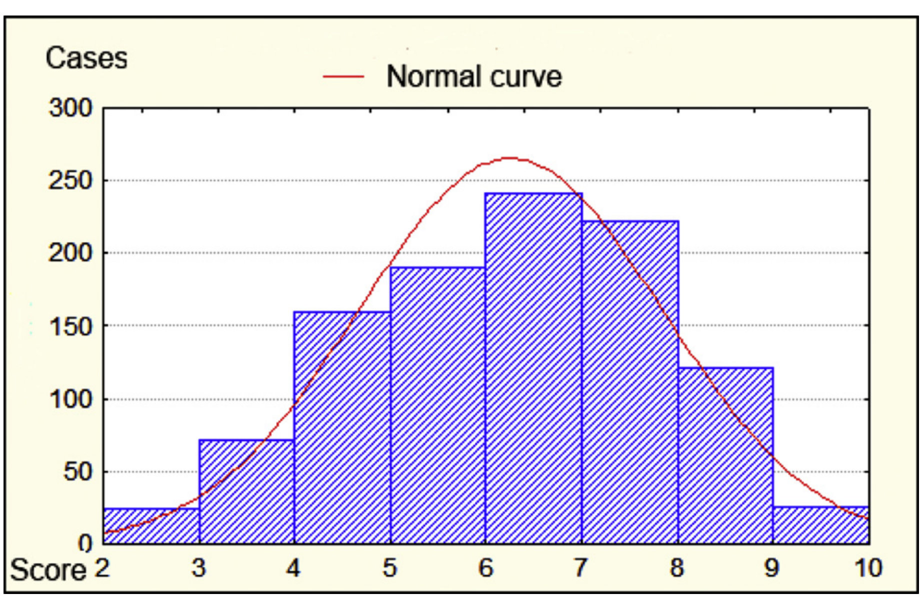

Fig. 1. Data distribution in the normal curve.

Table 1
Characteristics of the sample.

Characteristic	N	M	SD
Gender			
Male	599	6.34	1.66
Female	457	6.15	1.48
Type of school			
Liceum	447	6.65	1.51
Technical Institute	609	5.97	1.58
Geographical area			
North-West	314	7.04	1.28
North-East	146	6.45	1.65
Centre	147	5.53	1.63
South	255	5.88	1.56
Islands	194	5.90	1.40
Number of years using computers			
More than five years	453	6.37	1.56
Between three and five years	336	6.45	1.55
Between one and three years	222	5.93	1.58
Less than one year	40	5.19	1.70
No answer	5	6.11	3.00
Frequency of PC use at home			
Do not possess a PC	10	5.92	1.34
Less than once a month	10	4.68	2.11
Between once a week and once a month	15	5.22	1.95
A few times a week	256	6.11	1.54
Everyday	757	6.36	1.58
No answer	8	5.96	1.21
Frequency of PC use at school			
Less than once a month	223	6.14	1.54
Between once a week and once a month	247	6.54	1.68
A few times a week	571	6.19	1.56
Everyday	10	6.01	1.45
No answer	5	6.39	1.26

2.2.2. Types of skills

Organising and connecting textual and visual data (OCTVD): the skills required, for example, when semantically relevant links have to be established or data has to be labelled or transformed into graphics or vice versa.

Organising structured data (OSD): the skills needed, for example, when analysing data, recovering data and making inferences within structured data systems (archives, spreadsheets). These typically characterize the Simulation test.

Information Research (IR): the essential skills to evaluate critically information. These typically characterise the Inquiry test.

The tool considers dimensions that are given specific and detailed attention in other models or field of studies. For example, *VL* and *TS* items can be considered the most directly related to practical and operative knowledge, and they are usually at the core of ICT Literacy assessment, whilst *UTC* is similar to the NAEP (2010) section on Understanding Technological Principles.

The *EK* dimension, on the other hand, pertains aspects related to the ability of adequately interacting with others, which in a digital environment involves specific implications regarding the types of interactions granted by the device with significant effects on online responsibility and citizenship (as observed in the current debate: Boyd, 2007; Buckingham, 2007; James et al., 2009; Jenkins et al., 2009).

OCTVD refers to skills which are also included in the concept of digital reading as defined in the recent PISA Report 2009 (OECD, 2011). In this document print and digital reading are included within the same construct. Transposed to the digital world, this implies a greater ability to deal with and interpret different, but correlated information or information resulting from visual/textual transformations.

Similarly, *OSD* and formulating inferences involve high-level cognitive processes, which normally come into play when seeking to understand tables or archives. These can be appropriately enhanced and amplified into interactive forms by using adequate cognitive tools (Jonassen, 2000).

The *IR* dimension includes the ability to use information critically, a fundamental aspect of any form of critical thinking training. In the world of the Internet, characterised by information overload, this competence assumes its own particular connotation because knowing how to recognise relevant information, evaluate/assess its reliability and credibility is increasingly becoming necessary (UNESCO, 2008).

It should be noticed that some of these dimensions can be found in other literacies as "the new digital culture is built on a foundation of layers or levels that are superimposed on each other and integrated into a complex system" (Tornero, 2004, p. 53).

When such literacies are reformulated within the digital environment, some similarities are maintained, whilst new connotations emerge. Thus, for instance, *VL* is a form of literacy that was prevalent in the era of the ancient picture alphabet (Snyder, 1999) and which appears again today in digital literacy, even though mainly in the form of recognising interactive menus and interfaces. As Eshet-Alkalai (2004, p. 95) points out, this literacy "helps people to 'read' intuitively and freely, and to understand the instructions and messages represented visually".

To facilitate data reporting we subdivide them into three categories: *ICT Knowledge*, including *VL*, *TS*, *UTC*; *High-order cognitive skills*, involving *OCTVD*, *OSD*, *IR*; *Ethical knowledge*, which includes *SSO*, *RON* and *USTI*.

Our aim is to investigate digital competence articulated into the dimensions mentioned above with a sample of adolescents belonging to new generation of students.

Table 2
Correlation between iDCA scores and socio-demographic variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Gender *(1 if male)*	1											
2. Scholastic failure	.01	1										
3.Geographical Area Centre	−.02	.07*	1									
4.Geographical Area North-East	.21**	.03	−.16**	1								
5.Geographical Area Islands	.00	−.02	−.19**	−.19**	1							
6.Geographical Area North-West	−.01	−.02	−.26**	−.26**	−.31**	1						
7.Geographical Area South	−.14**	−.05	−.23**	−.23**	−.27**	−.37**	1					
8.Type of school *(1 if lyceum)*	−.14**	−.25**	−.22**	−.24**	−.06*	.22**	.20**	1				
9. Years using PC	−.06	.03	.02	.01	.04	−.03	−.03	−.10**	1			
10. Use PC at home	.11**	−.05	.04	.01	−.06*	.01	.01	.02	−.25**	1		
11. Use PC at school	.11**	.08*	−.17**	.22**	.19**	.08*	−.30**	−.30**	−.02	−.02	1	
12. iDCA	.06*	−.21**	−.18**	.05	−.11**	.32**	−.14**	.21**	.14**	.12**	−.01	1

**. The correlation is significant at 0,01 (2-code) *. The correlation is significant at 0,05 (2-code).

The question asked is: Does digital literacy amongst younger generations consist only of technical-practical knowledge and skills or does it also include a conceptual understanding of technology, socio-relational knowledge related to the web and high-order cognitive skills which could be involved in their use?

3. Method

With the aim of answering our research question, we conducted a cross sectional research to assess the digital competence levels of a sample of the new generation of Italian students.

The Italian school system has three main types of secondary schools (high schools): high schools, which prepare students for academic studies; technical institutes oriented towards the business world; and vocational institutes which prepare students for a more rapid introduction into the job market. The study was carried out in the period September 2009–January 2010 and involved 34 Italian secondary schools.

A stratified type of sampling was carried out starting from a preliminary coding of all the Italian secondary schools considering both the type of schools and the geographical area (North West, North East, Centre, South, Islands). The schools were randomly chosen proportionately to area and type of school, until 2 s-year classes from each school were identified.

A significant difference was immediately revealed as regards participation: the vocational institutes had more difficulty in accepting our participation proposal and in the subsequent technical phase of administering the questionnaires. Given the limited amount of data which could ultimately be collected from this type of school – data, which in any case, showed results that were of a much lower level than those from the other two types of school – we were compelled to exclude them from the general statistical analysis, thus downsizing the initial project which originally intended to guarantee a better national representation.

3.1. Sample

The research sample is made up of 1056 students attending second year high school (grade 9-10), 57% of which are male ($N = 599$), average age $M = 15.1$, $SD = .56$. 15% ($N = 156$) and are in a scholastic failure condition, and so over 15 years old. As regards geographical area, the sample is divided as follows: 30% ($N = 314$) from north-west Italy, 24% ($N = 255$) from southern Italy, 18% ($N = 194$) from the islands, 14% ($N = 146$) from north-east Italy and finally 14% ($N = 147$) from central Italy. In the whole sample, 42% of the subjects ($N = 447$) are from high school which prepare students for academic studies (*liceum*), while 58% ($N = 609$) attend technical institutes.

3.2. Questionnaire

The first version of the questionnaire, designed for adolescents (14-16 year-old high school students), was prepared in a paper questionnaire format.

The questionnaire is divided into two sections: a first section aimed at getting socio-demographic information about the respondents, as for example, age, gender, number of years using PCs, frequency of PC usage at home and at school; and a second section consisting of the iDCA tool, aimed at assessing the respondents' Digital Competence.

The first version of the iDCA was made up of 87 items and was tested in first and second year classes from three different high schools, and supervised by the researchers. This initial phase ran parallel to a further sounding of opinions by giving the questionnaire to a panel of experts to validate the content.

A multiple-choice format was chosen for the answers, formulating not less than 4 options for each item and attributing for each one: 1 point for each correct answer, 0 points for each wrong or missing answer.

After this first administration, the discussion with experts and a first item analysis, the resulting item group was implemented on a web platform to permit its experimentation on a wider scale and to verify the feasibility of a computerised administration of the questionnaire.

The developed online version was administrated in a pilot group of 220 first and second year high school students. Thanks to this testing a second item analysis was made.

For this type of validation we used item analysis techniques based mainly on the Classical Test Theory – TCT (Mc Alpine, 2002), considering the Difficulty Index (DI) and the Discrimination Coefficient (CD). In the case of the iDCA, it was decided to eliminate or modify the items with $DI < 0.1$ (too difficult) or >0.85 (too easy) (Mc Alpine, 2002).

Table 3
Average results for *ICT Knowledge*: VL, TS e UTC.

ICT Knowledge	Specific items (code and title)	% correct answers (single items)	% correct answers (categories)
Visual literacy (VL)	1. Computer signals	90%	88%
	2. Menu bars	86%	
Trouble shooting (TS)	3. Audio is not heard	90%	79%
	4. Working with video	76%	
	5. Printer does not work	81%	
	6. Possible damage caused by viruses	73%	
	7. Malfunctioning of the computer	77%	
Understanding Technological Concepts (UTC)	8. Requisites for using electronic mail	69%	54%
	9. Emails do not arrive: what are the possible reasons?	54%	
	10. What are the causes of slow net surfing?	43%	
	11. Associating tasks with the relative specialised software	60%	
	12. Tasks suitable for computers and for humans	57%	
	13. Searches using logical operators-1	53%	
	14. Searches using logical operators −2	55%	
	15. Completing a pseudo-programme in a pseudo-programming language	49%	
	16. The shortest path: a simple algorithm	48%	

Over the last two years the iDCA has been administered several times at school in Italy and also abroad. In particular, the tool has been validated through diverse applications in Italian schools and also translated into English and then adapted into Chinese to be administered to a sample of Chinese students (Li & Ranieri, 2010).

The reliability of the test was confirmed: Cronbach's alpha coefficient was satisfactory in both the Chinese (.77) and Italian (.79) samples (Li & Ranieri, 2010).

This led to the identification of the 35 final items intended for Italian high schools.

In this research we use the iDCA including all the 35 items (Cronbach's alpha = .82), which consider all the different aspects of digital competence, with a separation of the multiple choice items into digital competence theoretical subcategories (see Tables 3–5 in paragraph 4.2, which give the specific theme of each item).

The tool is taken online using the LMS Open Source Moodle in the school computer lab and supervised by the teacher (see www.digitalcompetence.org/moodle).

Considering the tool's pedagogical goal, students received detailed feedback as soon as they finished the test that gives them instructions for further study.

4. Findings

4.1. Descriptive analysis: socio-demographic variables

Fig. 1 and Table 1 summarise the general characteristics of the sample in consideration and the scores achieved, the average score out of ten is $M = 6.26$ SD = 1.58. If we examine the overall scores, they have a normal distribution, which is only shifted slightly to the right, with kurtosis: 0,527245 and skewness: −0,232756.

Table 1 shows respondents' average results compared to the different socio-demographic variables.

The higher average scores correspond to males ($M = 6.3$ SD = 1.66) as regards gender; to "liceum" ($M = 6.3$ SD = 1.66) as regards the type of school; to north-west Italy ($M = 7.04$ SD = 1.28) as regards the geographical area of origin.

As regards the number of years using PCs, the great majority of respondents are familiar with computers. Only 10% declare not having a computer at home; in comparison, over 70% use the PC everyday (this goes up to 95% if we include those who use them a few times a week). Moreover, the same amount of respondents (three fourths of the sample) has been using computers for more than 3 years. In this case the average scores go higher according to the frequency stated, going from $M = 5.19$ SD = 1.70 for those declaring owning a PC for less than a year to $M = 6.37$ SD = 1.56 e $M = 6.45$ SD = 1.55 for those declaring using PCs for more than 5 years and for 3–5 years respectively.

As regards frequency of computer use at home, the majority of the sample (72%, $N = 757$) uses the computer every day, 24% ($N = 256$) a few times a week, 1% once a week and once a month, another 1% less than once a month and a final 1% declares not owning a computer. Even in this case the average scores go higher in accordance with the frequency stated, going from $M = 4.68$ SD = 2.11 for those declaring using a PC at home less than once a month to $M = 6.36$ SD = 1.58 for those declaring using a PC at home every day.

On the other hand, as regards frequency of computer use at school, 54% ($N = 571$) of the sample declares a few times a week, 23.5% ($N = 247$) between a few times a week and a few times a month and 22% ($N = 223$) less than once a month. Less than 1% ($N = 10$) affirm using computers at school every day.

In this case, the highest average score, contrary to what was discovered as regards using PCs at home and years of PC usage, corresponds to the frequency between "once a week and once a month" ($M = 6.54$ SD = 1.68) rather than to the frequency "a few times a week" ($M = 6.19$ SD = 1.56) which represents more than half the sample (54%).

Table 2 shows the correlations between the students' scores in the iDCA test and the sample's characteristics.

Table 2 shows some significant correlations between the levels of digital competence tested and the socio-demographic variables characterising the sample. In particular, we can notice significant positive iDCA scores when respondents are from north-west Italy ($r = .32$; $p = .01$), attend high school rather than a technical institute ($r = .21$; $p = .01$), have been using computers for years ($r = .14$; $p = .01$) and

Table 4
Average results for high-order cognitive skills.

High-order cognitive skills	Specific items (code and title)	% Correct answers (single items)	% Correct answers (categories)
Organising and connecting textual and visual data (OCTVD)	1.Representing a text with a graph	77%	68%
	2. Representing hierarchical classes	69%	
	3. Hierarchic structure of a document	66%	
	4. Identifying keywords in a text	61%	
Organising structured data (OSD)	5. Organising data in a table	57%	43%
	6. Finding a missing value in a table	40%	
	7. Planning a simple budget	32%	
Information Research (IR)	8. Research on the Internet	65%	61%
	9. Search engine results	43%	
	10. Credibility of information	85%	
	11. Reliability of information	50%	

frequently use PCs at home ($r = .12$; $p = .01$). Moreover, there is clearly a positive correlation, although weak, between iDCA scores and gender ($r = .06$; $p = .05$); iDCA scores rise with the male respondents.

There are also some significant negative correlations: iDCA scores correlate negatively with being in a scholastic failure condition (r = .-21; $p = .01$), and this seems to suggest that students who had to repeat scholastic years basically got lower scores than regular students. From the table the absence of a relationship between iDCA scores and the use of PCs at school, also emerges.

Finally, some of the findings confirm other similar research results. For example, geographical difference is the strongest discriminating factor, with higher scores in the north compared with other areas, largely in line with what emerged from the Pisa tests (OECD, 2010). The type of schools attended is a determinant factor, students from *liceum* get higher scores than students from technical institutes.

An element which warrants consideration is the influence of variables related to the use of PCs: these data align with the findings from the recent PISA report 2009 (OECD, 2011), showing that students' performance is influenced by the use of PCs at home, whilst the use of PCs at school is irrelevant.

4.2. The sample's answers in the different sections of the iDCA

In order to analytically understand the scores' trend in the structured sections of our tool and to assess the respondents in the specific Digital Competence components, it was necessary to take into consideration the percentage of correct answers in the single items, grouped according to the above classification (see paragraph 2.2)

This first part of the iDCA includes a series of items related to the survey of knowledge in the three following areas: Visual Literacy (VL), Trouble shooting (TS) and Understanding Technological Concepts (UTC).

As can be noted in Table 3, the percentages of correct answers decrease progressively as we move from the VL item subsets to the UTC item subsets: in the VL items (item 1 and 2 on icon and toolbar recognition and other elements characterizing interfaces of the most common software) the average scores are very high, right up to 90%, with an average of 88% for the whole category.

Neither does the item group of the TS category present criticalities. Students, on average, seem to be quite capable of solving malfunctioning problems which are commonly encountered when working with computers and communication networks. They go from 90% for audio PC problems (item 3) to a minimum of 73% for problems caused by viruses (item 6), with 81% for printer problems (item 5), 77% for general computer malfunctioning (item 7) and 76% for trouble during video manipulation (item 4). The overall percentage of the category scores is 79%.

In the UTC category there is a sharp drop in the average scores (54% for the whole subset). The items in this category include various types of more conceptual skills, as for example, requisites for an email service (item 8: 69% correct answers), awareness that certain tasks can more adequately be carried out by humans and others by computers (item 12: 57%), using logical operators (item 13 and 14 with 55% and 53% average scores respectively), formulating hypotheses related to web (item 10: 43%) or email (item 9: 54%) functioning. Even the items related to logical skills (item 15) and to the understanding of algorithmic language (item 16) get average scores of 48% and 49% respectively.

Table 4 presents a summary of the average scores in the categories we considered for high-order cognitive skills.

As regards OCTVD the average score is 68%. The single items deal with the ability to organise a text graphically (item 1, 77% correct answers), manage information hierarchy (item 2, 69%), structure a document (item 3, 66%) and identifying key words and tags within a text (item 4, 61%).

Table 5
Average results for Ethical knowledge.

Ethical knowledge	Specific items (code and title)	% Correct answers (single items)	% Correct answers (categories)
Staying safe online (SSO)	1. Communication of personal data on the Internet	62%	61%
	2. Online payments	61%	
Respect on the net (RON)	3. Offensive online phrases	75%	67%
	4. Quoting information found on the web	59%	
Understanding social and technological inequality (USTI)	5. Technological gap between different countries: awareness	57%	44%
	6. Technological gap between different countries: communication	31%	

Table 6
Correlations between items in different iDCA sections.

Variables	1	2	3	4	5	6	7	8
1.Visual literacy/Trouble shooting (VL/TS)	1							
2. Understanding Tec Concepts (UTC)	.433**	1						
3. Organising and connecting textual/visual data (OCTVD)	.360**	.510**	1					
4. Organising structured data (OSD)	.315**	.512**	.416**	1				
5. Information literacy (IL)	.320**	.451**	.431**	.402**	1			
6. Staying safe online (SSO)	.154**	.253**	.236**	.169**	.251**	1		
7. Respect on the Net (RON)	.191**	.301**	.321**	.151**	.283**	.261**	1	
8. Understanding Social and Technological Inequality (USTI)	.028	.097**	.065*	.043	.089**	.090**	.165**	1

**. The correlation is significant at 0,01 (2-code) *. The correlation is significant at 0,05 (2-code).

The OSD skill proves to be the most critical element in the whole questionnaire, for which the respondents get an average score of 43% correct answers. Managing data in table form (item 5) gets 57% correct answers, while more specific tasks, such as, finding a missing reading in a table (item 6) simulating a spreadsheet or preparing a simple budget using the same tool (item 7) do not get over 40% and 32% correct answers respectively.

Even as regards the ability to evaluate information critically on the Internet (item 8), to consider its relevance and reliability, the scores go down to about 60% with a particular drop in the interpretation of search engine results; if we ask what are the factors influencing the order of results in a search, over half of the respondents seem to be unaware that this depends on the criteria adopted by the search engine (item 9, 43% correct answers). Briefly, subjects have significant difficulties in evaluating information relevance and reliability, as commonly found in literature (Kuiper et al., 2005) and also confirmed by the recent PISA report 2009 (OECD, 2011, p. 46) which points out that 83% of students do not go beyond the basic skill level when searching for and interpreting information online.

Table 5 summarises the results relating to the three subcategories within the dimension called *Ethical Knowledge*. In this section we can observe a mixed trend of average percentages of correct answers in each single item. In the first subcategory (*SSO*), referring to privacy aspects, the average score of correct answers for the item dealing with online communication of personal data is 62% (item 1), whilst for the online payments item it is 61% (item 2).

This result shows us that almost half of the respondents are not adequately aware of the risks when sensitive information is not protected. Similar results emerged even in other large-scale surveys (Livingstone, Ólafsson, & Staksrud, 2001).

The RON subcategory concerning mutual respect on the net received 67% correct answers. In particular, as regards offensive online behaviour (item 3 cyberbullying) the result is 75%, while the result achieved in relation to adequately quoting online information is 59% (item 4).

Understanding digital divide issues (USTI) proved to be one of the most difficult item subsets, revealing the students' scant consciousness of access problems that developing countries could have in Internet communication (average results 44%). About half of the students are aware of the technology gap between different countries in general (item 5, 57%), but only one third recognises that Internet band limits can have negative impact on communication (item 6, 6.31%).

4.3. *Relationships between items in the different iDCA sections*

In order to investigate in more detail whether teenagers' digital competence expands beyond the technical-procedural level, including a conceptual understanding of technology, adequate socio-relational knowledge and high-order cognitive skills, we focused our attention finally on the relationships between the different item subsets and considered the *VL* and *TS* items as a single dimension, as they both refer to practical knowledge.

Table 6 gives us an overall view of the mutual relationships between the different item subsets that make up the whole measure of digital competence. As can be noted the ethical dimension is the one that has the lowest correlation coefficient. In particular, it is interesting to note how the *USTI* subset is the least correlated to the others. With the exception of these items in the ethical dimension, most of the correlations are statistically significant. There are also significant differences between values. We can observe that the highest correlations occur between the scores related to the *UTC* category and the items involving cognitive implications (*OCTVD* [$r = 510$, $p = .001$], *OSD* [$r = .512$, $p = .001$], *IR* [$r = .451$, $p = .001$]). Scores related to more procedural items (i.e., *VL/TS*) still show significant correlation coefficients, although lower than the relative dimensions mentioned above (between $r = .32$ and $r = .36$).

The fact that the *UTC* category also presents a significant correlation with the *VL/TS* and *UTC* ($r = 433$, $p = .001$) categories highlights this dimension's possible bridging role between practical items and cognitive ones, an aspect which nonetheless requires further research.

5. Discussion and conclusion

The issue around digital natives' competences in ICT is at the core of a heated debate which also has significant implications for the institutional school identity and mission. According to an optimistic view, mere use of technology fosters new and inherently positive high-order cognitive and socio-ethical skills, and schools will only have to adapt them to this natural process.

In order to further research on the ITC skills of digital natives and their implications on teaching, we created a digital competence assessment tool that does not concentrate on the mere technical aspects of technologies, and we administered it on a sample of digital natives (considered as such because of their age).

This permitted us to evaluate significant aspects for a pedagogical reflection on the basis of a model in which digital competence is broken down into in different skill levels: practical, high-order cognitive and socio-ethical skills.

The resulting scores corresponding to the practical knowledge item subsets are of a good level, while they gradually and progressively go down as we get to the other item subsets, ranging from the conceptual understanding of technology to the awareness of online personal safety or social problems.

In particular, the findings of our survey show that the vast majority of students is able to perform very technical and procedural activities using computers and the Internet, but this should not lead to the conclusion that the new generation of students has developed sophisticated technological abilities as sustained by other authors (see for example Dede, 2005; Howe & Strauss, 2000; Oblinger & Oblinger, 2005; Prensky, 2001a; Tapscott, 1997). Our research study reveals that when students are asked to deal with more complex tasks such as using logical operators or distinguishing between tasks that can be accomplished by computers and others that cannot be accomplished by computers (*UTC*), their skills' levels are generally low.

Moreover, contrary to the claim that new generations of students are able to deal critically with a great amount of digital information (see, for example, Veen & Vrakking, 2004), we found that they do not spontaneously doubt the reliability of Internet information. Similar findings confirm results emerged in studies undertaken in other countries (Eagleton et al., 2003; Ravestein et al., 2007). For example, Kuiper et al. (2005) analyzed research on the use of web in K-12 education and concluded that "searching for information usually results in insufficient knowledge, understanding, and insight" (p. 309). This is also confirmed by the results of the ETS iCritical Thinking pilot tests carried out between 2004 and 2006. These tests showed, for example, that students are able to assess the credibility of a site if this does not require particular comparisons or inferential reasoning, but the percentage of students capable of making more complex site assessments, is rather low (Katz & MackLin, 2007).

Even on a more strictly socio-ethical level, though adolescents recognize that cyberbullying is questionable, they are little aware that online behaviour needs to be adequate for their own safety and respectful of privacy and they are completely ignorant about problems related to technological inequality and the digital divide. As already noticed, similar findings on Internet safety have been found in a large-scale research study carried out in 25 European countries, that led authors to conclude (Livingstone et al., 2011, p. 12): "When it comes to digital safety skills, it seems that the features designed to protect children from other users (if necessary) are not easily understood, by many younger and some older children".

Briefly, if we consider digital competence as a simple set of procedural abilities (a "copy and paste" literacy), we can conclude that our sample of students is digitally competent. On the contrary, if we identify it with a set of higher-order cognitive skills we get a totally different picture.

One of the main arguments against the optimistic representation of digital natives is based on the lack of homogeneity amongst young people due to their different levels of technology access and use (Bennett & Maton, 2010; Jones, Ramanau, Cross, & Healing, 2010; Thinyane, 2010). Our research shows that even the spectrum of adolescents' skills in ICT does not include high-level technological and cognitive skills homogeneously.

Indeed, apart from the considered sample's limitations and the limited number of items in the different subsets, our tool did not deal with the investigation of possible new forms of thinking different from those considered significant on the educational level, that is, critical-cognitive, logical and inferential competences. For example we did not take into account multitasking, today subject of great controversy, and which, according to some, represents a superficial form of thinking (Carr, 2010; Mayer, 2001; Ophir, Nass, & Wagner, 2009), but according to others could become useful for new professional profiles (Jenkins et al., 2009).

Basically, all this confirms the crucial role played by schools, which are faced with important decisions to take. In particular, schools should focus their attention on two objectives. On the one hand, they should make sure that the same basic technological abilities are acquired by everybody, thus eliminating the still existing disparities due to socio-economic and cultural gaps. On the other hand, schools should guarantee the integration of the notions and technological abilities which adolescents could acquire spontaneously through their own practices, within a more articulate cognitive framework, adequately related to other significant competences. This should be accomplished through specific educational interventions aiming at developing a critically, ethically and socially aware personality (Buckingham, 2003; Calvani, Fini, & Ranieri, 2010; Jenkins et al., 2009).

Our tool can also help schools in the light of this second goal, by offering the possibility to rapidly identify the critical elements that need intervention to foster the transition from spontaneous practices to practices of a better cognitive and social quality. From this perspective, the most critical areas are data organisation, information literacy and some aspects relating to ethical knowledge.

More work needs to be done for a better understanding of the articulate nature of digital competence among younger generations and of the internal relationships between the various components that this notion can entail. Above all, a lot of work is still required to link the data from national surveys with the results that international research is now starting to systematically present (see, for example, OECD, 2011).

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